

## Turbine-Driven Pumps Executive Summary

This study provides the performance evaluation based on industry experience during the 1987 through 1998 period for turbine-driven pumps (TDPs) in the pressurized water reactor (PWR) auxiliary feedwater (AFW) system and in the boiling water reactor (BWR) reactor core isolation cooling (RCIC) and high-pressure coolant injection (HPCI) systems. The objectives of component performance studies are (1) to determine the reliability of risk-important components and compare the results with estimates in probabilistic risk assessments (PRAs) and individual plant examinations (IPEs) and (2) to review the operational data from an engineering perspective to determine trends and patterns and gain insights into component performance.

TDP failure and estimated demand data was obtained from two databases. The Nuclear Plant Reliability Data System (NPRDS) provided data on component failures and surveillance test frequencies for the 1987-1995 period. The Sequence Coding and Search System (SCSS) provided engineering safety features (ESF) failure and demand data for the 1987-1998 period and some surveillance test failure data for the 1987-1995 period reported in Licensee Event Reports (LERs).

For the PWR AFW system and the BWR RCIC system, the TDP probability of failure on demand estimates were based on the combined ESF and surveillance test data for failures and demands from SCSS and NPRDS data sources. The ESF data (LERs) was from the 1987-1998 period, while the surveillance test data (NPRDS) was from the 1987-1995 period. For the BWR HPCI system, the probability of failure on demand over the 1987-1995 period showed a constantly decreasing trend. Therefore, the 1995 probability of failure is the recommended value. Table ES-A lists the TDP probability of failure on demand estimates developed in this study for the AFW, RCIC, and HPCI systems and the generic values referenced in this study (NUREG/CR-4550). Table ES-B provides the standby failure rates for each system.

**TABLE ES-A**  
**TDP PROBABILITY OF FAILURE ON DEMAND (1987-1998)**

<b><u>SYSTEM/SOURCE</u></b>	<b><u>LOWER BOUND</u></b>	<b><u>MEAN</u></b>	<b><u>UPPER BOUND</u></b>
NUREG-4550	1.1E-3	3E-2	1.1E-1
AFW system	1.3E-3	1.6E-2	4.6E-2
RCIC system	9.1E-6	2.0E-2	8.7E-2
HPCI system (1987-1998)	1.6E-3	3.3E-2	9.7E-2
HPCI system (1995)	8.5E-3	1.6E-2	2.8E-2

**TABLE ES-B**  
**TDP STANDBY FAILURE RATE (1987-1995)**

<b><u>SYSTEM/SOURCE</u></b>	<b><u>LOWER BOUND</u></b>	<b><u>MEAN</u></b>	<b><u>UPPER BOUND</u></b>
AFW system	1.4E-5/hour	1.8E-5/hour	2.1E-5/hour
RCIC system	9.1E-6/hour	1.3E-5/hour	1.7E-5/hour
HPCI system	2.1E-5/hour	2.9E-5/hour	3.8E-5/hour

The TDP mean probabilities of failure on demand used in plant-specific IPE studies were compared with the results of this study. For BWR RCIC and HPCI systems (1987-1995 data), all of the IPE mean values for the TDP failure on demand probability were within the range of this study and NUREG/CR-4550. Although the 1995 HPCI probability range is narrower, it is provided for information only for comparison with plant IPE mean values. For the AFW system, more than 90% of the IPE mean values were also within the range of this study and NUREG/CR-4550.

Failure rates, as a function of component-years, were compared among the PWR and BWR plant age groups (three groups, of approximately equal size, from older to newer plants by commercial operation date). For both PWRs and BWRs, the review of plant age groups did not show clear evidence of component aging or plant age effects on TDPs.

The evaluation of TDP subcomponent failure patterns demonstrated that failures of governor subcomponents were significant contributors to the TDP failures in the BWR RCIC system, while both turbine and governor subcomponent failures were significant contributors to the PWR AFW system and BWR HPCI system. Pump subcomponent failures were relatively insignificant.

Failures of TDP assemblies in AFW and RCIC systems were mainly due both to age/wear and maintenance/procedural deficiencies, whereas maintenance/procedural deficiencies were singularly predominant for the HPCI system.

During the study period, TDP failures remained high relative to other risk important component types, such as motor-driven pumps. Governor subcomponent failures were mainly due to maintenance/procedural deficiencies. However, the existing programs under the Maintenance Rule should improve overall performance of TDPs.